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can readily appreciate this agitation, this bowing and strutting, and all manner of quaint motions, as if the very last drop of his quaint lacertilian blood was on fire—for coyishly, and with all due deference, reclines before his lordship, his chosen mate, exerting all her chameleonic powers to hide her blushes by vain endeavors to match the colored pattern of her couch, with all the bronzes and browns at her command. He can withstand her charms no longer, and for the moment, laying aside all dignity, and the object of his affections not unwillingly submitting, in the next instant finds herself in the passionate embraces of her lord, who, to make sure that he has actually won his coveted prize, winds about her lithe form, perhaps in some mystic love-knot, his entire caudal extremity, and blinds her eyes, first on one side and then on the other, by the extension of the flaming ornament at his throat.

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# THE VARIABILITY OF PROTOPLASM.

BY CHARLES MORRIS.

ARE the other planets inhabitable, or is life confined to our earth? This is a question which has been widely debated with various conclusions. It is not probable and hardly possible that the surface conditions and temperature of any other planet of the solar system closely resemble those of the earth. Elsewhere in the universe may be very many planets approaching the earth in condition, and on which life may exist. But as regards the planets of our system the question at issue has hitherto been whether their surface temperature might or might not be near that of the earth. If the former they might sustain life. If the latter it was held that they must be lifeless.

But to say that life can only exist under conditions similar to those with which we are familiar is to make a bold assertion. It is presumptuous to take this little earth as the measuring rod of the universe. Life upon the earth arises from the activity of protoplasm, a highly complex organic compound. It is tacitly assumed that life everywhere must arise from the activity of protoplasm, and that protoplasm can only exist under conditions like those to which we are accustomed. This assumption cannot yet be disproved, but it may be questioned. There are some reasons for doubting that protoplasm, as we know it, is the only possible physical basis of life. We are beginning to recognize that the essential quality in protoplasm is its high atomed chemical composition and its molecular instability, not some occult property which can exist only in this special compound of C.O.H.N. In fact there is satisfactory reason to believe that in terrestrial protoplasm there frequently occur differences in composition, which differences may, for all we know to the contrary, be occasionally considerable. If it varies thus here, it may vary far more elsewhere, and under conditions of temperature and surface relations different from those of the earth, it seems not impossible that a basic organic substance may exist widely different in its chemical composition from that with which we are acquainted.

This question has been considered, from the chemical point of view, by several writers. The first definite declaration which we find on the subject, is that by Professor E. D. Cope, in a lecture before the Franklin Institute, February, 1874,[1] in which he sums up his conclusions as follows: "We are not necessarily bound to the hypothesis that protoplasm is the only substance capable of supporting consciousness, but to the opposite view, that the probabilities are in favor of other and unspecialized, but unknown forms of matter possessing this capacity." The same view was expressed in more detail in his paper entitled, "On Archæsthetism."[2]

Dr. Persifor Frazer has considered at some length the constitution of protoplasm in his paper entitled, "A Speculation on Protoplasm."[3] He concludes that "If the sarcode or protoplasm be susceptible of slight chemical changes, and in fact suffers such changes without losing the power to fulfill its function of repairing waste tissue, then in the progress of the decay of worlds, and the changes of external conditions consequent upon it, Darwin's law of survival must inevitably be felt where an accidental alteration of the substance of the sarcode and the resulting changes impressed upon the structure, enable one animal to live where others perished." He deems it possible that chemical diversities in protoplasm may become so great as to permit the existence of life under conditions widely different from those of our planet, and that organic beings may exist under greatly diversified circumstances of temperature and physical relations.

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[1] Consciousness in Evolution, *Penn Monthly*, Aug., 1875.

[2] AMER. NATURALIST, June, 1882.

[3] AMER. NATURALIST, July, 1879.

A similar view was later expressed by Professor Cope, who says: "It would be a monstrous assumption to suppose that consciousness and life are confined to the planet on which we dwell. Yet it is obvious that if there be beings possessed of these attributes in the planets Mercury and Saturn, they cannot be composed of protoplasm, nor of any identical substance in the two. In the one planet protoplasm would be utterly disorganized and represented by its component gases; in the other it would be a solid, suitable for the manufacture of sharp-edged tools."[1]

In a letter to the writer from Mr. John A. Ryder, in which he describes his observations upon the characteristics of protoplasm, he relates observed facts which clearly indicate chemical differences. Thus some forms of protoplasm were found to instantly coagulate in the presence of water, while other forms refused to coagulate. He found also considerable difference in color, transparency, general appearance and behavior when exposed to the action of chemical agents. He inclines to the conclusion that "the protoplasm of each species is a distinct organization, and its molecular composition may be of an approximately specific type for each form, with an inherent capacity for variation in the presence of the proper stimuli."

As to the peculiar forms assumed by protoplasm, long thought distinctive, it is now known that inorganic compounds, under certain circumstances, may take on precisely similar forms. This was first observed by G. Fournier in 1878, who found that mixtures of certain inorganic salts produced pseudo-organisms, resembling in appearance cryptogamic plants. Similar experiments made by D. Monnier and C. Vogt produced colloid masses exactly resembling organic cells and tubes. "The artificial pseudo-organic elements are enveloped in true membranes, possessing a high degree of dialyzing power, and giving passage only to liquids. They have heterogeneous contents, and produce in their interior granulations arranged in a regular order. They are, therefore, both in form and constitution, absolutely similar to the figured elements of which organisms are constituted."[2] These experiments have been recently repeated by Dr. H. Valin, with results still more marked and surprising.

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[1] On Archæsthetism, AMER. NATURALIST, June, 1882.

[2] *Comptes Rendus*, XCIV (1882), pp. 45-6.

To the conclusions as to the probable diversity of constitution in protoplasm, arrived at by the above-mentioned authors, may be added another, taken from a somewhat different point of view. There are physical as well as chemical reasons why certain elements, and they only, are the main constituents of protoplasm. This may partly arise from their abundance and general diffusion, yet other elements which take no part in the formation of protoplasm exist abundantly in all parts of the earth. But we may note the additional fact that carbon, hydrogen, oxygen and nitrogen are the only abundant elements which exist under conditions rendering active chemism possible. They all exist as gaseous constituents of our atmosphere, which contains no other element except in minute or local quantities. Two of them, oxygen and hydrogen, combine to form the only generally diffused liquid constituent of the earth. All other abundant elements exist as solids, and usually in the state of oxide.

Such is the general status of the chemical elements. All that are widely diffused, with the exception of atmospheric oxygen and nitrogen, exist as oxides. In consequence their chemical activity has nearly disappeared. At one period in the earth's history inorganic chemical action was probably very energetic. Now it has almost ceased to exist, through a general oxidation and solidification. Yet chemical activity has by no means ceased. Organic chemism has replaced inorganic.

Modern physiological study has reduced to a simple formula the essential principles of organic chemistry. Certain of the oxides are deoxidized. This is the basic principle of vegetable chemistry. The molecules thus produced are reoxidized. This is the characteristic feature of animal chemistry. A cycle of change is passed through, beginning with simple oxides and ending with the same simple oxides, while protoplasm forms the intermediate phase of the cycle. Vegetable chemistry consists of a successive series of deoxidations, by which carbon and hydrogen are released more and more from the grasp of oxygen. The molecular result of these successive changes, compounded in some way with nitrogen, constitutes the basic molecule of protoplasm. The exact method by which this is produced is not known. But it is known that in its production certain stable chemical compounds are decomposed, and that a complex chemical compound results, rendered highly unstable through the withdrawal of oxygen. The chemical stagnation to which oxidation has reduced the elementary constituents of the earth is partly overcome by this process of deoxidation, and active oxidation becomes again possible.

This active oxidation displays itself in the animal body. The elements concerned fall back towards the state of chemical stability from which they were removed, and the energy emitted during this descent is that which constitutes animal life. But if deoxidation is the chief chemical principle involved in the formation of protoplasm, why is it confined to the elements mentioned? A probable answer seems to be that these elements alone exist upon the earth under conditions which render such deoxidation possible. The other abundant oxides are solids, and therefore removed from any active influence of the agencies which aid the deoxidation of carbon. Some of these elements exist, either in their elementary or in a compound form, dissolved in water, and perhaps in consequence are found in protoplasm. Under proper conditions they might become active instead of passive agents in protoplasm. Some of them which are generally diffused, such as sulphur and phosphorus, seem to be essential constituents of protoplasm.

This review leads us to a significant conclusion. Protoplasm is a result of the successive deoxidation of the only elements whose physical condition renders them susceptible to this change. There is nothing to prove that such a process is necessarily confined to these elements, or that, if a state of affairs should arise in which these oxides existed as solids, and some other oxides took their place as liquids and gases, an organic molecule answering to protoplasm could not be produced by a like deoxidation of these latter elements. To affirm that carbon is the only element which can be deoxidized by the aid of sunlight, or by any form of free energy, is to affirm something of which we can have no knowledge, and it is possible, and even probable, that in other spheres whose atmospheric constituents may consist of simple chemical compounds analogous to, but not identical with, those of our atmosphere, a like process of decompounding and recompounding into complex and unstable molecules may be active, and organic forms exist. To this effect of course the presence of free energy is necessary, whether it be derived from a sun or from local sources of heat outflow.

It is, therefore, among the possibilities of chemical action that spheres whose temperature is much higher or much lower than that of the earth may be abodes of life. In an early period of the earth's history, when the elements which are now solid oxides were liquids or gases, some of them may have played the part which carbon now plays, and unstable molecules may have been produced resembling those of organic life. Perhaps some of the complex mineral constituents of the earth's surface are results of such an incipient organic evolution, as the mineral substances known as fossils are results of a more advanced evolution.

This idea leads us to a conception of a long series of efforts towards the evolution of organic life, as the earth gradually cooled, and one after another of its atmospheric constituents became reduced to solidity. Every such substance may, under the influence of heat emissions, have been aggregated with others into unstable compounds, which is the essential principle of organic development. The degree of chemical complexity and instability which could be thus produced would depend largely on the rate of rapidity of cooling. The advantage which carbon has had arises from its coming into play after the cooling of the earth had virtually ceased. Hence its period of activity has been much longer than that of the elements which may have preceded it in this organic process, and the results are immensely superior. But if our argument is of any value we seem to perceive tentative efforts towards organic evolution during the whole period of cooling of the earth's surface, while success in this direction was attained only after a stable condition of surface temperature was reached. In other spheres a long continued stability of temperature may have been reached under other chemical relations, and living beings composed of other constituents than those of earthly organisms have appeared.